Irrigation Pylons: Project Proposal

Tyler Dale, Nicolas Garcia, Ellen Halverson,
Kenneth Harkenrider, Trenton Kuta

1 Introduction

Flood irrigation is a common practice in the southwest United States. To water crops, farmers flood their fields with diverted river waters. Large valves separate canals and ditches from the fields; the irrigation process is controlled in real time by opening and closing these valves.

To initiate irrigation, a farmer opens one or more of these valves to let water flood into the fields. Over the course of several hours, the farmer must frequently walk out to the flooded fields and visually determine how far the water has advanced. Once the screen of water has travelled far enough, the farmer must close the relevant valve to cut off water flow - this is the end of an irrigation process. This flooding cycle must be done once every two to three weeks during the watering season.

We intend to automate the irrigation process so that the farmer does not need to directly interact with the valves or physically check the water level. By implementing a system of wireless moisture sensors and remote valve control, we can reduce the effort the farmer makes in an irrigation cycle and make the process more water efficient.

2 Problem Description

Ultimately, the problem is twofold - we must address the inconveniences inherent to flood irrigation and the consequences of overwatering.

First, irrigation is extremely time consuming; typical irrigations can last up to thirty six hours. The farmer is not active for this entire time period but because water pressure tends to vary and there is a risk of flooding nearby properties, it's necessary for the farmer to walk into the fields and check the progress intermittently. This is extremely inconvenient, as irrigation outings to check the water may take a few hours and irrigation schedules are generally not up to the farmer in the first place (ie, the farmer can only irrigate when given permission by water authorities).

Second, improper irrigation can result in overwatering. In the best case scenario, overwatering only results in excess drainage or pooling at the bottom of the property. This is non ideal because many of the regions that practice flood irrigation are currently experiencing drought; water is too precious a resource to be wasted on farmers' negligence. In the worst case scenario, overwatering can result in water damage to nearby properties.

To mitigate the risk of human fallibility and reduce the farmer's effort, we propose a network of pylons that will notify the farmer when the water reaches its desired level.

3 Proposed Solution

Instead of manually walking out to his/her field to check water levels, the farmer will be notified by a hub-centred network of pylons when the water reaches its desired level. These pylons will electrically sense the flood water and communicate with the central hub when the water screen has reached them. When the optimal pylon has sensed water (ie, the water has proceeded far enough into the field), the hub will remotely close the valves at the ditch - optionally, the hub can send a notification and let the farmer manually end the irrigation if necessary. Either way, the farmer only has to interact with the system once during an irrigation rather than having to rouse and check the water intermittently. Because the process is wireless, the farmer will not have to be confined to the property around the clock. Additionally, this system results in less water being wasted.

4 Demonstrated Features

Features we are expecting to demonstrate in May are as follows.

1) Water detecting pylons: Sensor pylons - which can separate soil and other debris from intake water - measures the amount of water which is passing the pylon and compares it with the desired value. When it reaches that amount, the pylon communicates with the central hub.
2) Communication to the central hub: The pylons communicate to a central hub most likely through Wi-Fi. The central hub is responsible for collecting data regarding the status of the pylons; with this data, the hub communicates with a valve control in addition to outputting the irrigation status to the farmer.
3) Valve controlled by central hub: To control when water is being outputted a stop valve will be used. The central hub will allow the user to open the valve remotely to begin the irrigation process. In addition, once the water has advanced sufficiently far to trip a specific pylon, the user can shut the valve from the hub and end the irrigation process.
4) User Interface: In order for the farmer to monitor the progress of the field there will be a user interface, which allows the farmer to see which pylons have already reached the necessary water level. Based on which pylons appear activated on the interface, the farmer can estimate the rate at which the water is moving and determine at which pylon/point in the field they should stop water output. The interface allows the farmer to open and close the valve whenever they see fit.

5 Available Technologies

To implement the desired features into our design, we will need to explore the available technologies in wireless communications, water-sensing devices, electrically-controlled valves/motors, power, and user interface.

For wireless communications, range and power consumption are the two major concerns. Wi-Fi appears to be a good candidate for the application because of its decent range, availability, and low integration cost. Bluetooth also has potential due to low power capabilities and low cost, however its shorter range may create obstacles in designing the system. Other technologies to consider for wireless communication are ZigBee and 6LoWPAN. The ESP32 chip incorporates both Wi-Fi and Bluetooth in an ultra-low power design that is also affordable.

For water-sensing devices, the presence of water on the ground's surface needs to be accurately detected. The easiest way to electrically sense the presence of water is measuring resistivity, which is what the $5 SparkFun Soil Moisture Sensor does. Alternatively, there are capacitive moisture sensors, like the Tindie I2C Sensor, but these generally cost about twice as much as the resistive sensors and have similar performance, so they are not a likely choice. Finally, neutron interaction can also be measured to determine moisture content, however these devices are highly expensive and less accessible, therefore they can be ruled out completely.

For valves/motors, we have the options to retrofit current field equipment or replace it. Retrofitting would allow for greater accessibility and lower cost to farmers, but would require more complexity and flexibility from our design. For the scope of our design, we will focus more on the integration of the valves into the hub-pylon system and less on the details of the mechanical valves.

For power, there are three cases to address: the pylons, the central hub, and the motors. Because the pylons will be dispersed in the field, portable power is key. To achieve this, we will incorporate a solar battery system. Meanwhile, the central hub will require greater power but can be stationary, so we will include a standard AC adaptor to be used near the home or farmhouse. Finally, the motors used to drive the valves will require greater power but also need to be portable, so a similar but higher-capacity power unit will be developed for the motors.

For the user interface, there are many options available, but in order to make it accessible and easy-to-use we will develop an iOS and/or Android app for farmers to use on their smartphone or tablet. In the case where more complex computation and analysis is needed, we will consider developing code in MatLab or a similar environment.

6 Engineering Content

The majority of the design for the irrigation control system is focused on the water detection system, which as the name implies, detects when the water reaches a specific point in the field. The technology used for this system is acknowledged in the previous section. For reference, a breakdown of the entire irrigation control system can be found on the next page marked as Figure 1.

Housing this system is the pylon proper, which requires a considerable amount of design and construction. The pylon housing design has to be incredibly durable to function properly while exposed to the elements, low profile to minimize the impact on the farming process, easy to find when the farmer wishes to harvest, and minimized heat retention in order for the electronic systems to work properly in the Southwestern heat. Above all, the pylon must direct water to the detection system and prevent debris from affecting the operation of the detection system. Another component of the completed pylon design is the Wi-Fi communication system, which will connect to the central hub and transmit once water reaches the pylon. The final system located in the pylon is the solar battery system, which will be required to power the entire apparatus in all conditions.

The pylon will be built in the four different sections and tested individually. The Wi-Fi system will be tested with the central hub to ensure that data packets can be transmitted between the two. The water detection system will be first tested with a normal potted plant to test the functionality and sensitivity of the measurement, after which the detector will be partially submerged to simulate actual operation. The solar battery system will be tested by leaving the panel outdoors for 2 weeks and test to see if the battery stores enough power for the operation of a pylon or valve control for 2 days. The pylon will be tested with a freshly tilled garden, to test if water flows as expected and mud does not hinder the operation. Finally, the pylon systems will be assembled together and retested in order to assure that the full system operates properly.

The valve control system requires a strikingly similar design, testing, and building process as the pylons, with the additional requirement of testing the mechanical system used to open and shut the valve. The other testing and design procedures are mentioned in the previous paragraph.

Finally, the central hub will be tested with both the pylons and the valve control. The communications testing will be similar, while integration with whatever user interface is selected will be tested in conjunction with all three communications systems.

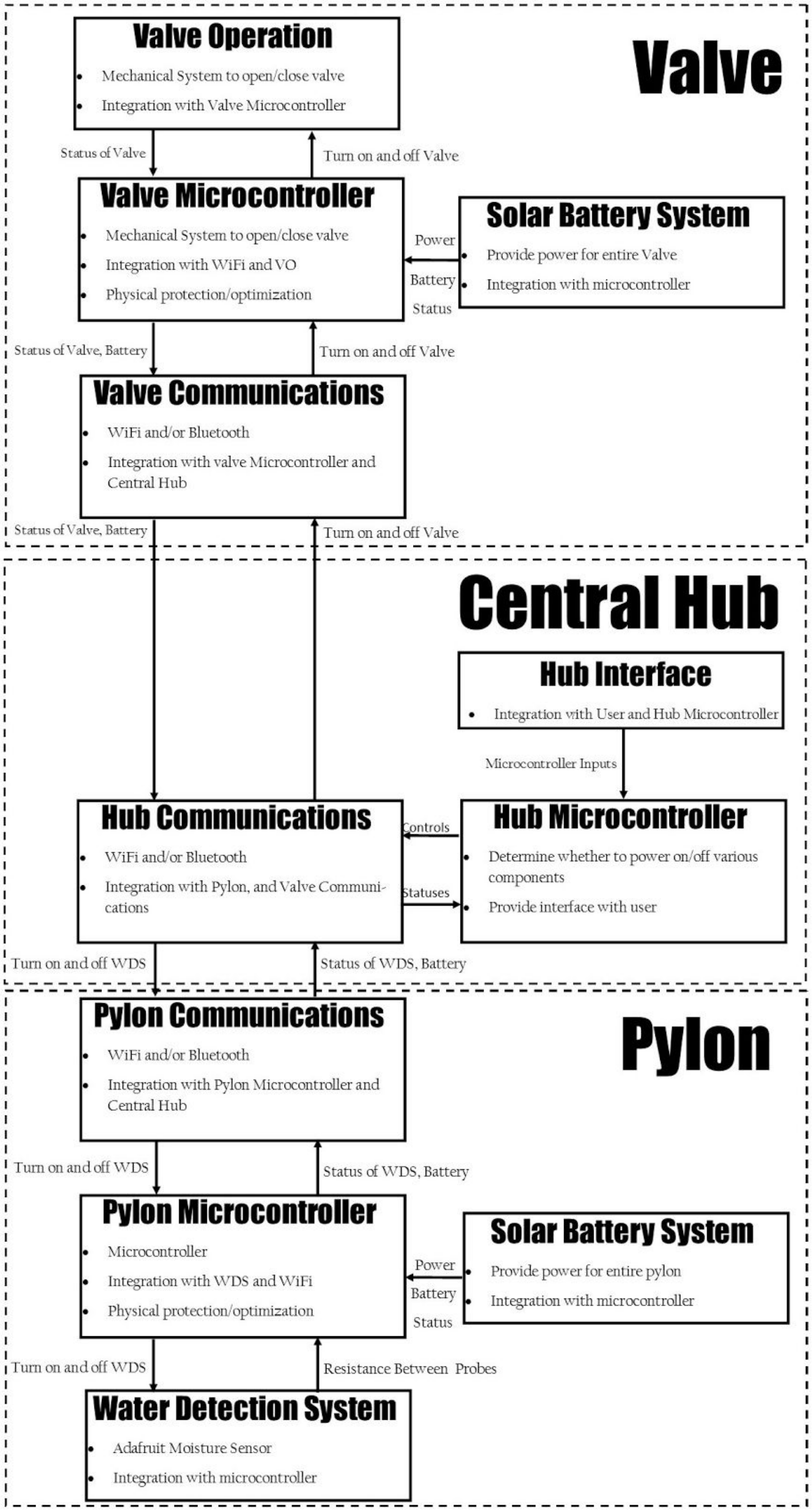

Figure 1: Flow Chart of the Irrigation Control System

7 Conclusions

This project is ideal for senior design because it enables our team to demonstrate the electrical engineering skills we have developed and create a product that will benefit farmers throughout the Southwest United States. Skills demonstrated include wireless communication, hardware construction, Internet of Things, and sensor appropriation.

Ideally, this project will result in a viable, useful, and marketable product for the agricultural industry. If nothing else, it will have provided the perfect proving grounds for the team's engineering prowess and give us the experience we need to go on as designers and creators.